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Art. IV.—*Some Features of the Coastline between Port Fairy and Peterborough, Victoria.*

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Abstract

Three types of coastline (mobile dune, consolidated dune limestone, and Miocene marine limestone) are described, with comment on the geological succession. Further evidence of a relative eustatic fall in sea-level of the order of 15 feet is adduced. Evidences of both drier and wetter climates have been found.

Physiography

The coastline to be described may be divided into three sections, according to the dominant geological structure, viz.:—

Mobile Dune Coast from Port Fairy to Warrnambool.

Consolidated Dune Limestone Coast from Warrnambool to Childers Cove.

Miocene Marine Limestone from Childers Cove to Peterborough.

Mobile Dune Coast.

Bordering the coast from Port Fairy to approximately the boundary of the City of Warrnambool are mobile dunes which consist of calcareous sand similar to the consolidated dune material on which they rest, and which is exposed at many places in the vicinity (Mahony, 1917; Gill, 1943). Behind the mobile dunes are extensive marshes formed by their damming the drainage; in some of these are found marine shells, proving former sea encroachment. The dunes have caused the formation of Belfast Lough, and have diverted the Merri River so that 6 miles of its course is roughly parallel to and close to the shore line. Parish plans in this area show many streams ending short of the coast at this fringe of coastal dunes (whether mobile or fixed). Dunes, formerly mobile but now anchored by marram grass, occur along the beach in Lady Bay (Warrnambool Bay), and resting on the consolidated dune limestone, within the boundaries of the City of Warrnambool. From Lady Bay to a point 2½ miles east of the Hopkins River, the mobile dunes, also resting on consolidated dune limestone, form the coastal fringe. Where the mobile dunes end and the cliffs, composed wholly of dune limestone, begin, there is a patch about 6 feet thick of consolidated bedded tuff that has been ejected from the Tower Hill volcano to the west-north-west. This deposit is probably an accumulation in a swale now partially eroded by wave attack.

Consolidated Dune Limestone Coast.

Pleistocene dune limestone is exposed in cliffs typically 60 feet to 100 feet high, but in places as much as 200 feet, that have been formed by wave action (Plate II., fig. 3). In the vicinity of Thunder Point (fig. 1), these cliffs occur for a short distance, but from 2½ miles east of the Hopkins River almost to Childers Cove they are continuous. The only rock exposed is dune limestone, except that Miocene marine limestone is present at the base of the cliffs east of section 15A, Parish of Mepunga. This stretch of coast follows generally the trend of a partially denuded swale passing to the east-south-east, the slope of the dune surface being towards the sea until the coastline cuts diagonally across the axis of the dune, after which the

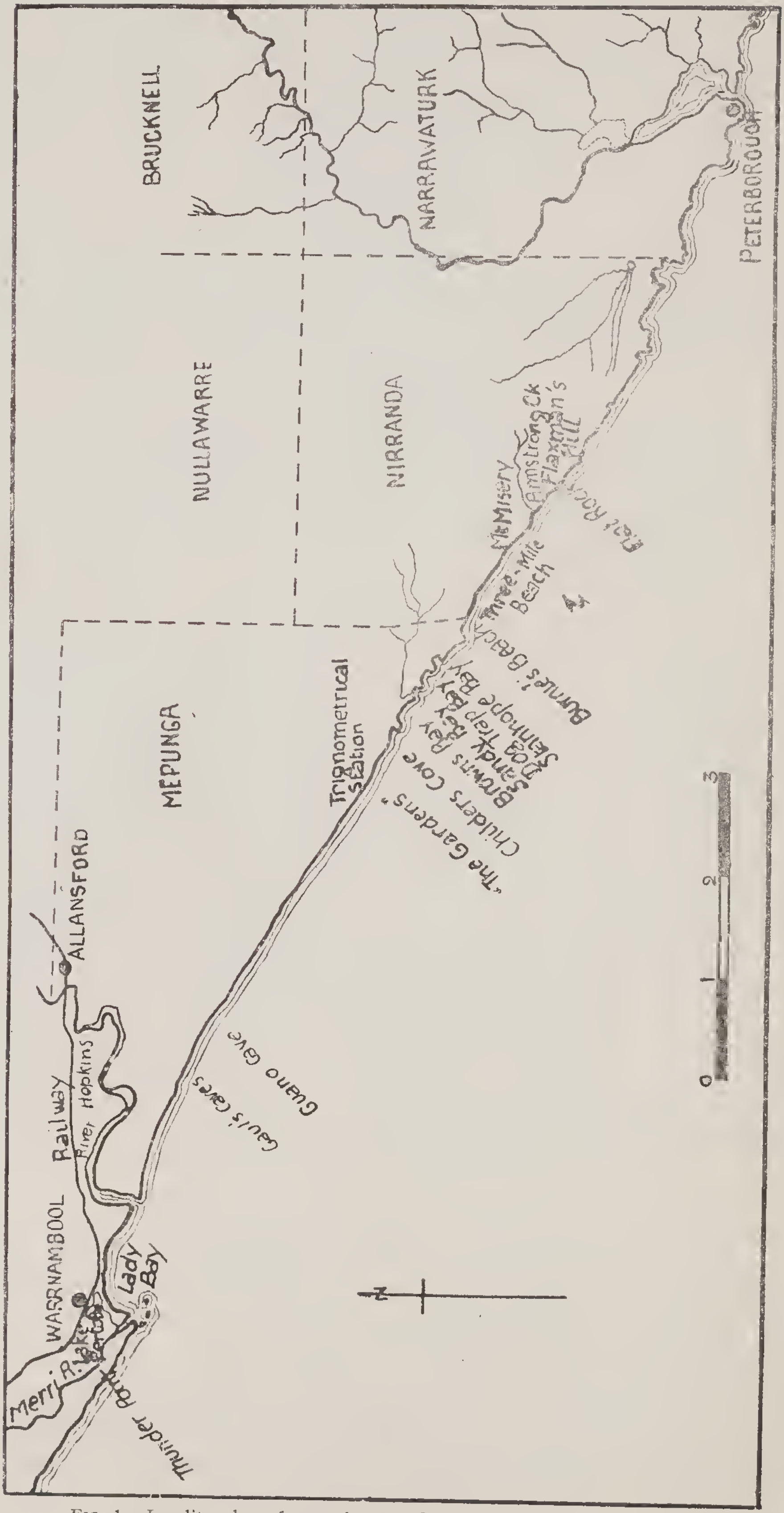

FIG. 1.—Locality plan of coast between Warrnambool and Peterborough.
Scale: Two miles = 1 inch.

slope is landwards. Three soil layers are generally present, and exeept where they have been indurated by secondary deposition, these soil layers have an important effect on the erosion of the eliffs. They are readily disintegrated by wind and water, and so hasten the breaking down of the cliff face.

At Warrnambool there are some five lines of dunes, while between the Hopkins River and Lake Gillear there appear to be only two lines, but these are very high. From that point eastwards there is only one line of dunes. No fossils were found in the dune limestone along the coastal section, exeept on a small headland less than 100 yards west of Guano Cave (fig. 1). The relationships of the rocks concerned are shown in fig. 2. The fossiliferous calcareous bed shown in the figure is about 10 feet thick, and its base is roughly 5 feet above high tide level. It rests on the Miocene marine limestone, and is covered by a fossiliferous soil layer, which in turn is covered by 60 to 70 feet of dune limestone in the cliff face. The 10-ft. bed consists of calcareous sand mixed with siliceous grit. Numerous marine shells occur in this bed, including ef. *Turbo* (*Subninclla*) *undulatus* (Martyn, 1784) and cf. *Neothais textiliosa* (Lamarch, 1822). These determinations were kindly made by Dr. F. A. Singleton. The sand, gravel, and fossils are firmly cemented by secondary calcium carbonate. In places, numerous flat pebbles of dune rock—typical beach pebbles—are found in the bed, which is very localized.

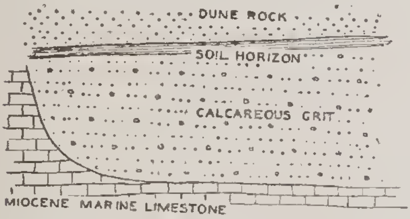

Fig. 2.—Fossiliferous calcareous grit, surmounted by a soil horizon, at base of dune series just west of Guano Cave. The fossiliferous bed is about 10 feet thick, and contains pebbles of dune rock.

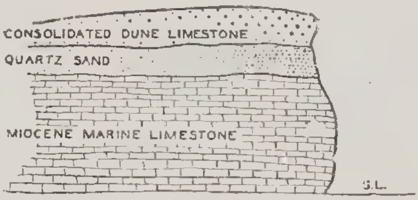

Fig. 3.—Sea cliff on headland forming east side of Stanhope Bay. The cliff is approximately 120 feet high, consisting of about 80 feet of Miocene marine limestone, about 20 feet of fine quartz sand, and about 20 feet of hard dune rock.

The indurated soil layer above this fossiliferous bed contains numerous land shells, and also a number of marine shells and bryozoan zoaria, many of which are also preserved as easts and moulds. The unusual mixture of land and marine fossils in this bed may be explained as a beach or sea floor which has become a land surface, and later covered by dune sand.

The inelusion of flat pebbles of dune limestone in the fossiliferous bed indicates that there were probably earlier dunes to seaward of the present ones. The author's earlier paper (1943) described how the dune rock exists below the present sea-level in the Warrnambool district.

Miocene Marine Limestone Coast.

This type of coast from Peterborough eastwards to Pebble Point has been described by Baker (1943, 1944) From Childers Cove to Peterborough it is characterized by vertical cliffs of fairly homogeneous yellow marine limestone with a dune-limestone cover. The bedding of the marine limestone is generally horizontal, but at the eastern end of Three Mile Beach (Plate II., fig. 1) it dips 4 degrees west. Fossils are common but poorly preserved, except for some of the more robust forms. *Lovenia forbesi* (T. Woods), *Ditrupa* (massed in distinctive bands), and a small brachiopod are common.

The homogeneous character of the limestone results in more even erosion of the cliffs than is seen at Port Campbell, where clays and limestones occur. From Childers Cove to Peterborough the sides of the rock stacks and cliff faces are almost vertical, slight projections resulting where more resistant bands occur. Along the dune limestone coast from Warrnambool to Childers Cove, apart from the general disintegration of the cliff face, erosion is accompanied by the breaking off of huge irregular blocks of rock, whereas along the marine limestone coast east of Childers Cove high vertical columns of horizontally-bedded strata break away. The difference is due, in the first case, to soil layers in the dune limestone. disconformities due to the building of other dunes on a planated surface formed on older dunes, and to cross-bedding; in the second case, to the general horizontality of the bedding and vertical jointing. Fissures (up to 6 feet across) are common along the tops of the cliffs in both types of coast; some are obviously old, temporary equilibrium of the stresses operating on the cliff face having been established. These fissures have assisted in the formation of caves, which are of fairly frequent occurrence. These latter have been formed by solution along the fissures, and by mechanical action where they have been exposed to wave attack. The inlets along the marine limestone coast are nearly always rectangular in outline with pocket beaches at their landward ends. This characteristic is due to erosion along major joint planes, which results also in the parallel orientation of rock stacks and islands with the sides of the inlets (cf. Baker, 1943).

Geological Succession

Marine Limestone and Dune Limestone.

Usually there is a well-defined soil layer between these two formations. The dune limestone immediately above the soil layer is often coarser than that higher up in the dune. The gentle undulating character of the soil layer at the surface of contact indicates that the old land surface was as physiographically mature as the present surface of the Miocene limestone further inland. At Broken Bay crystalline calcite up to 3 inches thick occurs in crevices of the dune limestone near its base.

Marine Limestone and Sands

In the Parishes of Mepunga, Nullawarre, and Nirranda (fig. 1), there are large quantities of fine-grained siliceous sand, which in the field occurrence look bluish. This sand is even-grained, unlike the sub-basaltic deposits at Warrnambool which often have coarse gravel in them and, still more frequently, clay. On macroscopic examination the bluish sands appear to consist entirely of silica, whereas the Warrnambool sub-basaltic deposits have large quantities of granitic felspar present. The sand area supports a characteristic plant assemblage known locally as " The Heath Patch." The sand is generally in the form of low dunes (now fixed by vegetation), this being especially the case in the vicinity of the coast. Well-defined dunes about 25 feet high occur near the trigonometrical station shown in fig. 1. The sands are comparable in many ways with those of the dunes of the Brighton-Frankston area described by Whincup (1944).

The stratigraphical position of these sands is shown in a cliff section on the east side of Stanhope Bay (fig. 3), where a thickness of about 20 feet of them is interbedded between marine limestone and the dune limestone. The sands are probably a residue from the denudation of the Miocene land surface. If the dune limestone is Pleistocene, then they are perhaps Pliocene in age. However, the sands on the open plain behind the dune rock (where they have not been covered and preserved by later rocks) may be Pliocene to Holocene in age.

Evidences of Change of Sea-level

Much of the evidence for changes of sea-level requires further critical study and correlation, but there are clear indications of a relative eustatic fall in sea-level of the order of 15 feet. Evidence of this has been cited by Coulson (1940), Edwards (1941), Baker (1944, p. 79), and the writer (Gill, 1943). Further evidence is to be seen in some of the beach formations along the Miocene marine limestone coast. At Flat Rock (on the coast south of the west border of section 50A, Parish of Nirranda), there is a long and well-defined beach ridge (Plate II., fig. 1); another can be seen on Burnie's Beach. Typical high marine limestone cliffs, obviously formed by the action of the sea, and with sea caves at intervals along the coast, are now never reached by the sea. The coast here is straight and open. Between these old sea cliffs and the present strand line is a wide sand flat with a beach ridge on its seaward edge.

At the east end of Three Mile Beach there is an old shore platform 12 to 13 feet above the present shore platform. Plate II., fig. 2, is a frontal view taken from the present shore platform at low tide. This platform and the old one are in homogeneous Miocene marine limestone. The old platform is covered with vegetated talus except at the edge, where it is swept by storm waves. The east end of the Three Mile Beach sections the shore platform, and shows boulders and some shells on its surface.

Shell beds, like those at Warrnambool, have been recently mapped at Port Fairy, about 17 miles further west. They are extensive, and the numerous shells in them are in such a condition as to indicate that they were laid down in quiet waters.

Volcanic Julia Percy Island lies off the coast in this area. A wave-cut platform about 15 feet above the present sea-level has been described by the McCoy Society's Expedition there (1937).

Around the coast of Australia there are many indubitable evidences of change of sea-level. Professor Richards (1939) has summarized these for Eastern Australia.

Climatological Inferences

The blue quartzose sands which constitute ancient dunes along the coast behind the high lithified calcareous dunes must have been formed at a time of more arid climate than the present, for they are now covered with a well-defined soil layer and strong vegetative cover. The rainfall at that time was too low to cause enough growth to anchor the sand, and so it blew up into dunes; but the rainfall is now sufficient to support a forest. The sands are not simply coastal dunes, but stretch inland for some miles. Hubbard and Wilder (1930), in discussing the validity of the indicators of ancient climates, remark, "Wind-blown sand usually suggests a region that is or has been arid." Hills (1940) suggests that the sand ridges of the Moorabbin-Highett district were formed during periods of relative aridity.

There are present also in the area under discussion, evidences of a relatively wetter climate. The parish plans show swampy areas across most of the plain between Allansford and Peterborough, but a large number of these have now been drained or have naturally dried out. Some Western District lakes have dried up within living memory. Apparently, at one time there was a chain of swamps and small lakes across this country, and in many of these beds of peat were formed. There are a large number of deposits of peat in the district (e.g.. in sections 32c, 47, 48, 50A, Parish of Nirranda), that at Brucknell (Herman, 1913) being the best known. A windmill bore on section 50A, Parish of Nirranda), near Flat Rock, passed through 8 feet of peat and 7 feet of clay before reaching the Miocene marine limestone of the bedrock. Ferguson (1920) maps peat in the Port Fairy area. These deposits suggest that wetter conditions than at present prevailed in the past. In discussing peat as a climatic indicator, Giles (1938) names "abundant (though not excessive) and well-distributed rainfall" as one of the conditions favourable to the formation of peat. However, he quotes areas of relatively small rainfall where considerable deposits of peat occur (p. 408), and appears to infer that the deposits were laid down under climatic conditions the same as the present. The recent large climatic changes associated with the Ice Age need to be kept in mind.

Thus it appears that in the area dealt with in this paper, the climate has been both drier and wetter than it is now.

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Description of Plate

Plate II.

Fig. 1.—View looking west along Three Mile Beach, showing former sea cliff, beach ridge, &c.

Fig. 2.—Showing former shore platform at east end of Three Mile Beach. The photograph was taken at low tide from the present shore platform.

Fig. 3.—Consolidated dune limestone cliffs a few hundred yards west of Guano Cave. Note soil horizon behind figure. This photograph was taken by Mr. Alex Wilkins, of Warnambool.

PORT FAIRY—PETERBOROUGH COASTLINE.